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APPROACHES TO PROMOTE ACTIVE, CONCEPTUAL
LEARNING IN A PEDAGOGICALLY HYBRID
INTRODUCTORY STATISTICS COURSE

by

Brittany L. Allred

A report submitted in partial fulfillment
of the requirements for the degree

of

MASTERS OF SCIENCE

in

Statistics

UTAH STATE UNIVERSITY
Logan, Utah

2009

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Acknowledgements

I would like to thank my major professor, Dr. Kady Schneider, for her help and support with this project. Additionally, I would like to state my appreciation to Dr. Adele Cutler and Dr. Jürgen Symanzik for the use of their Stat 1040 resources which aided in the development of the library materials for this project. Most importantly, I would like to express my gratitude to my family, friends and study mates for their patience and never ending encouragement in my journey through the graduate program.

Running Head: ACTIVE LEARNING IN INTRO STATS

Abstract

Statistics education is an active area of research where discovery-based learning is becoming more prominent. This project reviews how the USEI and GAISE recommendations can be implemented in the statistics classroom. Further, the project describes the creation of a library of classroom materials for an introductory statistics course. The results are also discussed from implementing various library materials, along with the student response to hands-on learning techniques.

Introduction

The American Statistical Association (ASA) gathered together a committee of statistics instructors in 1999 to discuss and assess the needs of undergraduate statistics education. The committee decided on a vision and mission, which they deemed the Undergraduate Statistics Education Initiative (USEI). The vision of the USEI according to the ASA was:

1. To create opportunities for students to avail themselves of sound undergraduate educational programs in quantitative reasoning.
2. To give a broad quantitative foundation for further study in specialized disciplines.
3. To increase quantitative literacy within the modern workforce (ASA, 2008).

Later in 2003 the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Project, funded by a grant from the ASA, expanded upon the USEI's vision of undergraduate statistics education. The GAISE project was to create "goals for students, based on what it means to be statistically literate" (Aliaga, 2005). Specifically the goals from the GAISE Project were:

1. Emphasize statistical literacy and develop statistical thinking;
2. Use real data;

3. Stress conceptual understanding rather than mere knowledge of procedures;
4. Foster active learning in the classroom;
5. Use technology for developing conceptual understanding and analyzing data;
6. Use assessments to improve and evaluate student learning (Aliaga, 2005).

The GAISE College Report calls for undergraduate statistics educators to create a dynamic curriculum base to stimulate statistical thinking, to have conceptual understanding of various statistical topics, and to teach the tools to analyze real data. One way to implement such a curriculum is to create and implement a library of classroom materials for the undergraduate classroom.

Previous research suggests including technology and real world examples in the introductory statistics course is essential for developing both positive student attitudes toward statistics, and a clear understanding of the basic statistical concepts taught in an introductory classroom (Mills, 2004). There are various resources available in print (news articles, books, etc.) and on the web (applets, modules, etc.) to assist instructors in creating an active learning atmosphere in the statistics classroom. However, most of the resources lack a framework for how to incorporate them into the topics of the introductory curriculum in order to be beneficial for student learning.

Learning statistics requires students to think actively and analytically, instead of passively, to which most students are accustomed. Joan Garfield, from the University of Minnesota and GAISE Group Chair, drafted ten principles describing how students learn statistics. A few of the principles include students constructing their own knowledge base, engaging in learning where they exert more work to understand concepts, relating life experience to new situations, and having

“opportunities to express ideas and get feedback on their ideas” (Garfield, 1995). Hence the goals of this project are to:

1. Develop a library of classroom materials to implement in an undergraduate statistics class to promote active learning.
2. Implement a hybrid course layout which integrates both traditional (lecture style) and alternative (discovery-based) teaching methods, as proposed by the statistics education reformers to improve the attitude of undergraduate students at the introductory level (see Garfield, 1995 Moore, 1997).
3. Establish methods to best teach conceptual understanding in the introductory statistics class based on the USEI and GAISE recommendations.
4. Use student and instructor response to assess the materials implemented in the classroom to gauge impact on student conceptual understanding and student preference for the various teaching methods.

Review of Literature

Many studies have previously been conducted comparing traditional teaching and alternative teaching in the statistics classroom. This section reviews previous experimental studies as well as qualitative projects/reports which measure student attitude and conceptual understanding to meet the following objectives:

1. Examine previous studies of various implementation styles and achievement measures.
2. Study previous projects to understand the current statistics education climate and reforms.
3. Identify the strengths and weaknesses of previous studies and projects to inform this project.
4. Draw conclusions from previous research to formulate research questions for this project.

Review Procedures

Sixteen experimental-based research articles were located by the following procedure. ERIC via EBSCOHost aided the main search of experimental studies, with additional information from GoogleScholar, and the *Journal of Statistics Education* via the American Statistical Association. In addition to the sixteen experimental studies located, fourteen project-based articles were found by scouring the indices of the *Journal of Statistics Education* to gauge the current climate of statistics education.

The criterion for articles included in this review was that the study or project must discuss the outcomes of an alternative teaching style implemented in the classroom or lesson plans/ideas for teaching in the introductory statistics classroom. Key words used to search for literature included:

- introductory statistics education, study action research
- statistics education*
- statistics teaching
- statistics education, action research

Experimental Studies – Study Characteristics

A systematic review approach was used to analyze and synthesize the literature of the experimental studies. For this purpose a code sheet was developed (Appendix A) to include the following characteristics: research design, sample characteristics, and methods and purpose. The coded information was recorded on a Literature Review Table (Appendix B).

Research design, experimental design type. Ten of the studies (62%) found were action research, four (25%) were purely quasi-experimental design and one study (6%) was a combination of action research and quasi-experimental design. The action research studies focused on how the instructor implemented the active learning teaching style, and the student response to the teaching style. The quasi-experimental designs were comprised of an instructor teaching two identical

sections of the same course. One section was taught using traditional lecture method, while the other section was taught using an alternative method to promote active, hands-on learning.

Research design, method of measurement. Four studies (25%) did not clearly report a method of measurement that the instructor used to determine how the teaching methods impacted the students' learning. Of the remaining studies, five (31%) drew upon student feedback or student surveys and six (37%) used some form of testing to measure the effect of the teaching methods (quizzes, pre- and post- tests, take home exams, regular in-class exams). Three studies (18%) used a combination of testing and student surveys. Most studies were action research, thus mainly student surveys assessed learning and attitude, instead of formal testing.

Sample characteristics, sample size. Three studies (18%) neglected to report the class size participating in the study. Five studies (31%) reported a smaller class size (less than 70), while eight (50%) of the studies reported larger class sizes (greater than 70 students). Many of the studies with large samples were comprised of multiple sections of the same course.

Sample characteristics, school type. Ten of the studies (62%) did not report the university size where the study took place. Of the remaining six studies one (16%) was a small university, one (16%) was a mid-sized university and four (33%) were large universities.

Sample characteristics, participant education level during course. Eleven (68%) studies were general education introductory undergraduate courses, with varying student majors, such as business, criminal justice, education, liberal arts, psychology, and others. One (6%) study was a graduate level introductory statistics class; another (6%) study was a second year, non-introductory, statistics class for psychology majors.

Methods and purpose, study purpose. As expected, the main purposes of the studies varied. However, all of the studies had the same general theme of improving student learning. Two studies

specifically looked at enhancing lectures to promote conceptual understanding, improving student attitude toward statistics, and encouraging subject mastery.

Methods and purpose, implementation method. Twelve (75%) studies specifically reported how the “new” teaching method to improve student learning was implemented. Of those studies reporting an implementation method, all had different ways the method was put into practice. One study created an “I Need a C” club which required class attendance, participation in the supplemental instruction sessions, and quizzes taken before class on the assigned book reading (Bushway, 2002). Another study revamped lecture delivery along with group activities to learn the material, in addition to using the computer software MYSTAT or SYSTAT to promote more hands-on learning with statistics software (Steinhorst, 1995). Three studies implemented a student data collection element. The students were to pick a topic of interest and then apply what they learned statistically to the collected dataset throughout the term.

Methods and purpose, materials created for the curriculum. Nine studies (56%) either did not create any specific materials to be used in the study, or did not report what the authors created. Studies which created materials to be implemented during the course had several combinations of the following: classroom activities or in-class experiments to be utilized within a group setting, media articles, guided notes, and student-centered lectures. Two studies implemented computer modules.

Methods and purpose, dependent variable. Only two (12.5%) of the sixteen studies reported a specific dependent variable tested in the study. The goal of one study was to determine if group work aided in a better learning atmosphere with more conceptual understanding and higher grades. The other study’s goal was to see if classes with cooperative learning groups in an alternative style class scored higher on tests than students in the traditionally taught class.

Methods and purpose, experimental setting. All of the studies took place in a college classroom. However, four studies (25%) included a laboratory section on top of the college classroom setting. Likewise, another study (6%) had, in addition to the regular classroom section, an online section which met in the classroom once a week.

Qualitative Reports – Project Summaries

Each project-based article was briefly summarized to locate the themes of the current statistics education climate (Appendix C). The articles showcased how other instructors implemented new statistics teaching methods in their classrooms to improve student learning, which influenced this project. Additionally the articles and project reports suggested ideas for how to incorporate active learning activities in the statistics classroom by discussing specific lesson plans.

Themes. The themes of the previous projects representing the current statistics education climate are as follows. One theme espoused by several authors was the emphasis of student data collection and teaching students the randomization of data collection (Adolph, 2007; Melton, 2004; Vaughan, 2003). The second major theme found in the previous projects was making real life statistical connections through the use of examples and problems to engage student interest. It was suggested by Howley (2008) that instructors exploit their student's previous knowledge and understanding to build upon statistical concepts being taught in the classroom. Another theme in previous projects was capitalizing on group work; either groups for projects assigned by the instructor, or small groups to work on an in-class problem. Garfield (1993) suggests small groups maximize individual learning. One project by Tudor (2006) discussed the implementation of an online course conducted through Blackboard which had objective-based lessons that included notes, readings, problems, activities, and graded discussions.

Conclusions of the Experimental and Project Literature. This review of literature establishes a need for this project which will examine the implementation of a hybrid introductory statistics course, combining both traditional and alternative teaching elements. One aspect lacking evidence from the previous studies and projects is the compilation of a library of classroom materials, and the implementation of the materials in the introductory course. An additional aspect to examine in this project is the variety of the type of materials used in the classroom (e.g. guided lecture notes, articles from the media, applets, in-class activities and experiments), the number of times the materials are implemented, and how they are implemented. Finally, another characteristic to qualitatively assess during this project is student attitude toward learning statistics through their response and feedback to the hybrid instruction style of the course.

Research Methods

Project Overview

This action-based research teaching project implements a hybrid teaching style incorporating traditional (lecture style) and alternative (discovery-based) teaching. A library of materials will be created and implemented in this study. The library consists of guided notes, articles from various sources of media, applets, in-class activities and experiments. Items in the library will include an instructor's guide outlined with learning objectives and directions on how to implement the article in the classroom. In addition to the instructor's guide, student guides will be created for class use or homework assignments.

The sample for implementing the curriculum materials in this project was comprised of an introductory statistics class of forty-five students (12 males, 33 females, average student age 22 years, standard deviation of 5.3 years, median age 21). The project was implemented in the fall semester 2008 at Utah State University, Logan, Utah (school population: 23,000). Students in the

class were non-statistics majors. Majors represented in the class varied widely from elementary education to exercise science, with the majority of students from the College of Education. Most students took the course to meet the University's quantitative literacy requirement, or as a prerequisite for a research methods course required by the student's major.

Prior to the project commencement, a set of objectives for the course was developed by Dr. Kady Schneider to follow the required textbook for the course, *Statistics Fourth Edition*, by Freedman, Pisani, and Purves (Freedman, 2007) (Appendix D). After the approval of the course objectives by the course supervisor, Dr. Adele Cutler, a library of materials (approximately 130 articles) was created to be implemented throughout the project.

Description of the Library of Materials

Following recommendations from the USEI and GAISE College Report to "stress conceptual understanding rather than mere knowledge of procedures," a set of guided notes was compiled from the notes of experienced introductory statistics instructors for each chapter in the textbook, meeting the outlined course objectives (Aliaga, 2005). The goal of the guided notes was to help students put more emphasis on concepts through examples and applications, instead of spending class time writing down lengthy definitions. As such the notes included material from the text as well as current examples with statistical content. The instructor set of notes included solutions to the example problems, as well as occasional advice on how the materials from the library could be implemented in specific places in the notes. The student version of the notes looked similar to the instructor set of notes. However, blanks were left for the students to fill in during the lecture for definitions, key words, and examples. During the course, the guided notes were posted on the University's web-based learning system, Blackboard, in both a PDF and a

document format. Students could either print the notes prior to the lecture or take notes using their personal laptop computer.

To expand statistical thinking and literacy – another goal of the GAISE College Report – articles with statistical content from current newspapers, magazines, etc. were included in the library of materials and used in class discussions, group work, or homework. Student and instructor guides were also created to go along with each article. The instructor guide included article summaries, citations, and objectives the article met along with instructions on how to use the article for in-class discussions or homework assignments. The student guide typically included a worksheet with instructions, a brief summary of the article, a web link to the article with questions, or an activity corresponding to the article.

The GAISE College Report emphasizes the importance of teaching students to think conceptually about statistics. One method to guide students in this conceptual thinking is the implementation of various technologies in the classroom. Following the GAISE technology recommendations, an extensive web search for applets was conducted prior to the project. Applet instructor and student guides, similar to those listed above, were designed with instructions on how to incorporate them in a classroom setting or as homework. In addition to applets, Microsoft Excel activities were integrated into the curriculum as the technology aspect for the course.

In addition to the notes, articles and technology items in the library, in-class activities, and experiments were also produced for discovery-based group learning. The majority of the in-class activities were the author's original work. Like other library materials, the activities and experiments also included an instructor and student guide. The instructor's guide outlined the objectives the activity/experiment met, the supplies needed to implement the experiment, and directions on how to best engage students in the activity/experiment. In order to encourage students

to discover statistical concepts from their own discovery and hard work, as Garfield (1995) suggests, many of the instructions on the student version of the activity/experiment were purposely left vague.

Library Evaluation Plan

In order to assess student learning and measure the student feedback of the materials in the library, students were assigned discussion questions through the Blackboard Discussion tool. As a feature of Blackboard the discussions were set up for student privacy, and only the instructor could view and respond to the student's posts. Discussion responses were recorded anonymously into the database, with only the pertinent student responses relevant to the posed question. Students had the opportunity to opt out of the recoding of their responses into the database for this project, but they understood completing the discussions was part of the course grade. In addition to student feedback through the discussions, the instructor kept a daily reflection journal. The journal included feedback on how students responded to the materials used in-class, difficult topics for students to understand, and improvements needed for the library materials.

Assigned homework provided another method to examine the usefulness of the materials in the library. Instead of completing weekly quizzes on the material taught in class, the students were assigned homework with each chapter in the textbook and were given one week to complete the assignment. A typical homework assignment included a chapter reading from the text, relevant homework problems from the text, and an item from the library (i.e. applets, articles, and activities). The responses to the homework questions from the library materials aided in measuring the impact on students' conceptual understanding from the articles. Additionally, homework responses led to improvements of the articles.

Description of Results

Guided Notes

For the first week of class the instructor provided the students with the guided notes until the instructor verified all of the students had access to Blackboard (Appendix E and F). From an instructor point of view, the guided notes saved valuable class time, allowing more time to work examples, conduct experiments, and lead in-class activities. However, the set nature of the guided notes made it difficult for instructor to modify them in response to students understanding. One student stated: "The guided notes in my opinion are a very good idea. It gives a good over view of what we'll expect in the homework as well as on the exams. Also helps me pay attention to what we're going on and not to get so lost." The students for the most part appreciated the guided notes, but some thought the fill-in-the-blanks were too obvious.

Media Articles

The articles in the library from the media sources brought a real-life feel to the course curriculum (Appendix G and H). Over the duration of the semester, the students began to recognize that what they were learning was not just something needed for a course exam, but a subject informing their everyday lives. Many of the media articles were used in homework assignments, and summaries of the articles were used as exam questions. Additions to the media portion of the library were continual as statistics appeared in current news issues. In a discussion response about the media articles, a student commented: "The articles are helpful and I like them because although reading can be time consuming, it is good to mix things up and they also illustrate the real-world application of statistics and math (which helps keep me, a non-mather, engaged and interested)." Throughout the course students commented and asked questions, in class and during office hours, about news clips or articles they read and the statistical applications. Whenever students made these comments, they demonstrated that they understood statistically what was discussed in the

media they were viewing. For the instructor these comments indicated the students paid attention to what they were learning and could make a real world connection outside of the classroom setting.

Technology

The two main technology tools implemented during the course were applets and Microsoft Excel. When assigned an applet activity for homework many students struggled at first to understand how to work the applets, a surprising discovery, considering most of the students belong to the technology savvy generation (Appendix I and J). At the beginning of the semester the students' inability to operate the applets proved a major barrier to learning with the applets. Over time, and with more applets integrated into the homework, most of the students liked the applets once they figured out how they worked. A common point of feedback from the students was they liked the applets because they could run the applet over and over again until they understood the concept that the applet was demonstrating. One student said, "I [...] like the applet programs because it lets me fool around with a concept until the little light bulb in my head turns on. It is sort of a hands on way of approaching different subjects." Another student stated, "With the applets we have a visual way of learning the material which is how I learn best."

One applet used successfully with the whole class was an applet designed by Dr. Schneiter, which displayed scatter plots and required students to guess the correlation of the points (see Appendix K). The applet had a similar layout to the game show Jeopardy, allowing easy division of class into teams for a friendly statistics competition. The team closest to the actual correlation value earned the most points. From the instructor's journal:

"The [correlation] applet went over surprisingly well! I broke the class up into 3 sections, about 15+ students in each group. I had the first group 'cast their vote' about the correlation and then the next group would see what the 1st group had picked and then change

their vote. By the time we got to the 3rd group, they had the best advantage, because they could pick an r value that had not been picked, and have a better chance of getting it right.

“The students really got into the guessing of the r value, and got pretty competitive. The annoying thing about the applet was that the groups were too big, so not everyone got the chance to have input, and along with that problem, since the groups were big, they took too long to decide on what value they wanted, and that ate up time. Overall though, I would use that applet again in teaching correlation.”

The other technology element invoked in the course was Excel. Before using Excel, the students understood the software was not a statistician's first choice of a statistical analysis program. However, it was likely they would be exposed to Excel in their professions, and it was important they understood how to manage the basic statistical formulas in the software (i.e. average, standard deviation, correlation, scatter plots, etc.). To motivate student interest in using Excel, a homework assignment was created using the 2008 Summer Olympic data (Appendix I). Students were given an Excel spreadsheet from the Olympics containing the number of participants from each represented country, and how many medals each country won during the games. After brief classroom instruction on the statistics formulas in Excel, the students were then asked in the assignment to find the average, standard deviation, correlation coefficient and create a scatter plot of the data. Following the assignment the students were encouraged to use Excel or calculators to find the average and standard deviation in subsequent assignments. After the assignment one student commented, “I enjoyed the assignment on Excel. I liked it because it was different, I didn't have to read, and I could apply what we learned to real stuff that has happened while I've been alive.”

In-Class Activities and Experiments

The in-class activities and experiments piqued the most student interest and student engagement. One experiment conducted during the class focused on the concept of measurement error, using a similar experiment to the one suggested in the course text with a few variations (Appendix M). Students were divided into groups, provided a different measuring device per group (i.e. yard stick, small ruler, 3×5 note card, and others), and asked to measure the width of the desks in the classroom. After measuring, the students discussed ways to account for the variation in the measurements. Surprisingly, the students did not anticipate the difference in the measurements, but discovered that the standard deviation would be an appropriate way to account for the differences in the measurements. One student commented:

"I think the reason I liked the activity so much was because it was so evident how easily data can be misrepresented. We each had the same measuring tool and still some people got incredibly different measurements. I think that it was great not only because it clearly defined the principle but that it was not just another example on the board. We actually actively participated in the learning."

Another in-class activity which stirred student involvement and engaged them in conceptual learning was an applet activity centered on confidence intervals (Appendix N). The students were given a Tootsie Pop and asked to think about the slogan, "How many licks does it take to get the center of the Tootsie Pop?" Presented to the students was the scenario that they were a group of researchers for the Tootsie Pop Company. The students were given the task to estimate the average number of lick it takes to get to a center of a Tootsie Pop. Because of time constraints the students did not conduct the licking of the candy in-class. Instead, the class assumed that when the experiment was conducted the average number of licks to the center was 300 (the average used in the applet). The class went through the activity with the applet, relating it to the licks of a Tootsie

Pop. At each new concept presented in the applet, questions were posed to the students to get them to think more in depth about confidence intervals, and what they meant in terms of real data. In addition to the class discussion with the applet the students completed a Pre- and Post-Applet worksheet to free-write about the activity (Appendix O). This activity helped students conceptualize the idea of confidence intervals by visualizing the concept in a real life setting. The students seemed to like the activity, and really got into it as evidenced by the questions the students asked. After the activity students had the following feedback:

- “I liked that the tootsie pop example [it] was a little more real life than some of the other problems we have done in the past. I like the problems that I can actually imagine statisticians working on. [I] know the tootsie problem is a bit far fetched, but [I] can picture [the situation] better than a couple statisticians flipping coins etc.”
- “The applet helped me understand that the bigger the sample the more accurate the confidence level will be in predicting the true average (or percentage...or whatever). It was nice to be able to see it in play because it makes more sense to actually see it instead of think about what it should be. I feel like the ‘real life’ application was just as useful as the examples from the book because those could be applied in real life too...more so than other math classes.”
- “[...] the Tootsie Pop exercise help[ed] me understand and put all the information together, because I have been struggling with that. I get all the formulas but then I don't know what to do. This [applet] with those applications with the percentage of confidence level just help[ed] me in the way of finally putting everything together.”

One of the more successful discovery experiments was called “Which is it to be? t or z ?”

(Appendix P). In the experiment student pairs were provided with a stick of Starburst candy (12

pieces) and a bag of Mike and Ike's candy (about 50 pieces). Students were presented with a situation about their grandma's candy dish which was full of every flavor of the Starburst and Mike and Ike, except lemon candies because she loved the lemon flavor. The grandma thought there was never enough lemon candies in the packages compared to the other flavors. The goal of the experiment was for students to conduct a hypothesis test to determine if there were fewer lemon candies than expected in each package. This experiment required students to employ what they had been taught about the normal z-test and student's t-test, and apply that knowledge to a new situation without a deep understanding of the hypothesis testing concept. The activity forced students to review their notes and to help one another learn. At first the students hesitated when working on the problem without any instructor help, but after a little encouragement students grouped up and began working on the experiment. Once the groups finished the experiment a class discussion was conducted to determine the consensus of the experiment, and to talk about the process of hypothesis testing. One student commented after the experiment:

"I really loved the activity today. It was good working in a group, because it showed that we were all on about the same page, mostly understanding the concepts, but still a little vague. It helped me feel like I was in sync with the rest of the group. The activity was excellent! The two different examples were very good, as they made us use the z score and the t-test. The Starburst activity really made us think and redo things quite a few times, which was good, because then we understood the concept better and I think it will stick. This was probably my favorite activity so far in this class, as it really helped solidify the concepts we were learning."

Discussions

Using the discussion feature on Blackboard to measure student attitudes toward statistics and student responses to the materials in the library was unexpectedly very beneficial to student learning. Questions posed to the students during the discussions improved their learning through the assessments as recommended by the GAISE Project (Appendix Q). Students received credit for completing the discussions which added to their final homework grade. Students were permitted to miss four discussions (due to family emergencies, missing class, illness, etc.) throughout the semester without penalty to their grade. The discussions asked students to explain concepts taught in class in their own words, and to provide feedback on the library of materials, allowing the instructor (author) to identify problem topics and student attitudes toward statistics. After the students posted a response, the instructor read and responded to every discussion posted by the student in a timely manner.

Whether the students realized it or not, the process of writing the responses to the questions reinforced what they were learning in class and applied the material to the world around them. The final discussion question for this project asked the students to share their opinions about the discussions. The majority of the students appreciated the opportunity to build a relationship with the instructor, and most stated they felt the discussions were beneficial to their learning. A few students, ironically those who did not complete the discussions or homework, thought the discussions were not beneficial and a waste of time. Many students commented on how they had a hard time remembering to complete the discussions, which was an odd response considering a discussion was assigned for each class meeting covering new content. Students were also reminded to complete the posted discussion before they left class. Students responded, positively and negatively to the discussions, by saying:

- “The discussions have been really important I think. For one - they help us students express our fears to you in a private setting. Also it helps repeat some of the things we've learned so that it sticks better. For a student like me, I need to study A LOT in order to understand the material and these discussions help me to begin that process. I know a lot of the people in class know what they are doing and enjoy math, but [...] math and I have a bad relationship and I have appreciated these discussions because I can vent a little - which makes me feel a little less uptight about the assignments and tests. The discussions make me feel better about struggling, because I know you know how I feel and are there for us. Thank you for that.”
- “[I] had no problem with the discussions when [I] remembered them. [It] was hard to remember to write something brief because when [I] thought about math [I] only remembered to [do] the homework that involved the math problems. [The] discussions were a great idea because it forces us to think and comprehend what we did in class.”
- “As I student I found that most of the time the discussions did not improve my learning. I think it was more of a stressor to have the discussions because it was difficult to remember to complete them after leaving class. I did, however, feel like it was a good way to communicate with the instructor on how I felt. I liked giving my input on what I needed more help with in class and which activities I liked best.”

Overall the discussions allowed for detailed assessment of the materials created in the library and a method to improve student learning through a unique assessment method.

Conclusion

The project met the outlined goals discussed in the beginning. The library of materials and implementation methods promoted active learning in the classroom. Having a variety of ready-to-use materials made teaching the introductory statistics enjoyable for the instructor, and made

learning statistics fun for the students. The variety of materials also helped to create a lively classroom community where the students got involved in their learning experience, rather than just sitting and listening to the lectures. The group activities aided in student learning, and provided an opportunity for the students to get to know one another, thus making the students more comfortable when asking and answering questions in class.

The hybrid teaching style of this project benefited not only the layout of the course, but also student learning of the material. The mix of traditional style lecture with alternative discovery learning elements spiced up the class for the students, since the class was not the same thing every time. The hybrid style also helped maintain student attention during the class meetings, while the students experienced learning statistics through a variety of mediums. At the end of the semester, students who were worried about understanding statistics at the beginning had a grasp of basic statistical concepts and an improved attitude toward statistics.

The library materials, with minor modifications, expansions and corrections, were implemented with another introductory statistics class the following semester, spring 2009 (50 students, 11 males, 39 females, average student age 20 years, standard deviation of 1.9 years, median age 19). The requirements and class layout for the spring class were identical to the fall class, with several of the same materials used in both classes. The personality of the spring class differed from the fall class. The students were shyer and more difficult to get involved in classroom discussions and activities. For the spring class, the results and feedback from the hands-on learning were about the same as the fall. Students liked the hybrid style of the class, the loved variety of the hands-on experiments, and they felt the amount of activities integrated into the lectures was adequate. However, one stand-out difference in student opinion concerned group work. A few students in the spring class expressed their disdain for group work, whereas when asked a similar

discussion question in the fall, none of the students in that class expressed the same opinion about group work. The students expressing such an opinion about group work in the spring were seemingly no different from the other students in their class or in the fall class.

The execution of this project found several applications and implications for the practice of teaching statistics to improve student attitude toward learning and comprehension. One application that could be immediately implemented in any statistics classroom is the hands-on learning activities. In this project, short, simple activities were used to engage students in learning statistical concepts, and students responded positively to the learning activities. Group work does improve learning as it takes student learning to a new dimension. Another application that could easily be applied in other statistics classes are the discussions. The discussions allowed for assessment not only of the materials used in the class, but also for student learning. Discussions were a tool, without any pressure or stress on the students, like a quiz or exam, to measure what they did and did not understand about the material covered in class. Also, discussions allowed an open forum between the student and instructor, fostering a comfortable learning environment. An additional implication from this project for statistics teaching, as discussed in the research, is using real, current data. By using real data and scenarios the students could relate to, they were able to make connections to the concepts taught in class, and therefore they understood the concepts more precisely. The media is filled with stories containing statistical concepts, which, with a little bit of work, can easily be added into the introductory statistics classroom.

One of the limitations of this project when it was originally conducted was that it was only carried out with one section of introductory statistics with forty-five students and the materials may not be as beneficial in larger classes. Another limitation with the project was that the majority of the students in the class were not true freshman. The average age of the class (22 years) was four

years older than the typical freshman introductory class. The older age of the class may be a confounding factor because the students are a little more mature, and already have those study skills a true freshman class lacks. Also, unlike some research suggests, this project lacks the implementation of assigned group project and oral presentations. Including such a project, in addition to the extensive group work during class, would have not only overwhelmed the students, but also the instructor in this setting.

Many future projects and studies could be developed to expand upon this project. One such project could be a computer learning module that acts as a study guide for each topic in the introductory statistics curriculum. A study investigating the impact of the applets used in the project on student learning could be beneficial to how instructors teach statistics. Another future project would be to see if the materials created in this project are as successful with a larger class, including what adaptations of the materials would be needed for a larger class. As the statistics education climate continues to evolve and expand, more projects and methods of teaching will need to be developed so students get the best exposure to and education of statistics. This project was step in the desired direction.

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Appendix A – Literary Review Code Sheet

Title:

Author(s):

Source:

Summary:

A – Research Design

- Experimental Design Type
 - Action Research
 - True Experimental Design
 - Quasi-Experimental
 - Baseline
- Method of Measurement
 - Pre/Post testing
 - Student Attitude Survey
 - Test/quiz/exam
 - Formative evaluations
 - Student Feedback – Journals, etc

B – Sample Characteristics

- Sample Size: _____
- School type
 - Large University
 - Small Liberal arts
 - Community College
 - High School
- Participant education level during course
 - High School AP
 - Introductory Undergraduate
 - Non-Introductory Undergraduate
 - Graduate

C – Methods and Purpose

- Implementation Method (Reason)
 - Computer modules
 - Applets
 - Lecture design
 - Guided notes
 - Activities
 - Data Collection
 - Media Articles
 - Use of Blackboard (or something equivalent)
- Study purpose
 - Enhance lectures
 - Improve student learning
 - Subject mastery
 - Improve attitude
 - Conceptual Understanding
- Materials created for the curriculum
 - Computer applets
 - Computer modules
 - Guided lecture notes
 - Classroom activities
 - In Class Experiments
- Dependent variable: _____
- Experimental setting
 - Classroom
 - Laboratory
 - Classroom and lab

Appendix B – Literary Review Table

Article Info	Title	Experiences with Authentic Assessment Techniques in an Introductory Statistics Course	Using Small Groups to Promote Active Learning in the Introductory Statistics Course: A Report from the Field	Developing and Assessing Students' Abilities to Interpret Research
	Author	Chance	Keeler	Forsyth
	Summary	Student assessment, Used Semester long projects – flexible teaching style, Used , computer software to teach, Journaling – used to reflect on previous work, Used grading rubrics – more consistent	“The purpose of this study was to investigate whether a cooperatively structured course where students work in groups would produce higher grades and result in greater retention of students in the course than the traditionally structured instructional method.”	Reading and understanding research, Students given vignettes of research with questions to answer to gauge statistical understanding
Research Design	Design Type	Action Research	Action Research	Action Research
	Method of Measurement	test/quiz/exam , formative evaluations, student feedback w/ journals, oral presentations, take home exams	test/quiz/exam	test/quiz/exam
Sample Characteristics	Sample Size	63	40-100 (several classes)	
	School Type	Small private university	Mid-size university -- rural	
	Ed. Level	Intro Stat - Undergraduate	Intro Stat - Undergraduate	
Methods and Purpose	Implementation Method	Data Collection and Labs	group learning	
	Purpose	Improve student learning, assessment techniques	Improve student learning	Improve student learning
	Material Created	classroom activities, in class experiments, group learning		
Other	Dependent Variable		does the group work aid in learning/understanding/higher grades	
	Setting	class and lab	classroom	classroom

Article Info	Title	Predicting Acquisition of Learning Outcomes: A Comparison of Traditional and Activity-Based Instruction in an Introductory Statistics Course	Students' Attitudes Toward Statistics: Implications for the Future	The Benefit of Student-Generated Data in an Introductory Statistics Class
	Author	Geske	Mills	Boger
	Summary	2 instructors with 2 section – one section traditional, one section activity based, Activity based – scientific method, Results: Activity based felt like the class was disorganized but felt equally, involved in the course as those in the traditional setting, No difference in the final between traditional a activity based learning on the final, Emphasis on the teacher student relationship	Using technology in the classroom and evaluating student attitude, A worthless study – conclusion student attitude is improving	Quantify student response to student-generated data, Results – “Students generating their own data reported significantly less positive perceptions of the relevance of statistics in their chosen field of study than did students who were provided with data by the instructor”
Research Design	Design Type	quasi-experimental		quasi-experimental
	Method of Measurement	student attitude survey, self-efficacy survey, classroom environment survey	student attitude survey	student attitude survey
Sample Characteristics	Sample Size	156	203	60
	School Type	large university	large university	Large university
	Ed. Level	Intro Stat – Undergraduate	intro stat – undergrad	non-intro undergrad
Methods and Purpose	Implementation Method	activities, data collection, lecture design		data collection, computer program (SPSS)
	Purpose	enhance lectures, improve student learning, subject mastery, improve attitude, conceptual understanding		Improve student learning
	Material Created	guided notes, classroom activities, in class experiments		
Other	Dependent Variable			
	Setting	Classroom		Classroom

Article Info	Title	Helping Criminal Justice Student learn Statistics: A Quasi-Experimental Evaluation of Learning Assistance	Using Classroom Assessment Techniques in an Introductory Statistics Class	Cooperative Learning and Statistics Instruction
	Author	Bushway	Goldstein	Giraud
	Summary	Ways to get students in the criminal justice program to understand and pass their stat class – 4 test groups with different requirements, SI does help students pass – known from other research, Pre-class book quiz helped most students	GOOD JUSTIFICATION FOR THE DISCUSSIONS – VERY SIMILAR IN THIS STUDY, Classroom assessment – feedback and CATs generally help student understanding	Cooperative learning (randomly assigned working groups) performed better than the traditional students, “The current study compares the students in a cooperative learning class to those in a lecture class in terms of their scores on identical tests.” Scaffolding students – those more prepared paired with those who were less prepared, Several confounding factors – time of day and the set up of the classroom – I don’t think enough to really affect the outcome
Research Design	Design Type	quasi-experimental	action research	quasi-experimental
	Method of Measurement	test/quiz/exam	formative evaluations -- classroom assessment techniques, and student feedback	Exams
Sample Characteristics	Sample Size	92 + 86 control		95 (control and treat combined)
	School Type			large university – public
	Ed. Level	intro undergrad	intro undergrad	intro undergrad
Methods & Purpose	Implementation Method	attendance, read the book quizzes, study skills, (SI's), WebCT		Lecture design, group learning
	Purpose	Improve student learning		
	Material Created	computer modules, SI's		
Other	Dependent Variable			Test scores
	Setting	classroom		Classroom

Article Info	Title	Teaching Introductory Statistics: Some Things I Have Learned	Data Exchange Activities in a Large Introductory Statistics Class: Effects, Limitations, and Possibilities	Computer Aided Statistics Instruction Protocol (CASIP) Restructuring Undergraduate Statistics in Psychology: An Integration of Computers into Instruction and Evaluation
	Author	Kirk	Lazarte	Rah
	Summary	Teaching techniques to reduce test anxiety, teacher-student interaction, reducing memorization, do assignments on time, frequent reviews for retention	Activities engage learning more than plain lecture – even with large classes	Creating a test bank for questions, students monitor understanding and can retest several times – promotes more student-centered learning, Kind of worthless – too dated
Research Design	Design Type	Action research	Action research	Action research
	Method of Measurement			
Sample Characteristics	Sample Size	110		
	School Type			
	Ed. Level	Intro undergrad	Intro undergrad	Intro undergrad
Methods and Purpose	Implementation Method	JMP and SAS Programs	Technology, group learning	Computer module, EXSTAT and QPWs
	Purpose	Enhance lectures, improve student learning, subject mastery, improve attitude, conceptual understanding	Enhance lectures, improve student learning	Improve student learning, subject mastery, improve attitude, conceptual understanding
	Material Created		Classroom activities	Computer modules
Other	Dependent Variable			
	Setting	Classroom and lab	Classroom and lab	Classroom and lab

Article Info	Title	A Study Comparing Traditional and Hybrid Internet-Based Instruction in Introductory Statistics Classes	Web-Based Statistical Readings for an Introductory Statistics Course	Learning Statistics By Doing Statistics	Developing Material for Introductory Statistics Courses from a Conceptual, Active Learning Viewpoint
	Author	Utts	Wisnabaker	Smith	Steinhorst
	Summary	Hybrid class – online and meet once a week	Given reading to understand and analyze subject specific materials to the students interest	Data collection or using recent data is important for student interest, Learn by doing, writing, speaking, Team projects – includes a list of projects	More hands on learning – better attitudes and test scores – no data to back up these results, just a description of what was done in the study
Research Design	Design Type	Action research and quasi-experimental	Action research	Action research	Action research
	Method of Measurement	pre/post testing	Student attitude survey	Student attitude survey	
Sample Characteristics	Sample Size	200-250	34		
	School Type	Improve student learning, subject mastery	Large university		
	Ed. Level		Intro graduate class	Intro undergrad	Intro undergrad
Methods and Purpose	Implementation Method		Media articles, blackboard equivalent		Lecture design, activities, MYSTAT or SYSTAT
	Purpose		Improve attitude	Conceptual understanding, subject mastery, improve attitude	Conceptual understanding
	Material Created		Media articles collected		Lecture & conceptual material, test material
Other	Dependent Variable				
	Setting	Classroom and online		Classroom	classroom

Appendix C – Statistics Education Climate Literature Review – Summary of Information

- **Work Cited:** Melton, Kim I. "Statistical Thinking Activities: Some Simple Exercises With Powerful Lessons."

Summary: Meaningful data collection and variation in data collection with several different learning activities.

- **Work Cited:** Gnanadesikan, Mrudulla, Richard L. Scheaffer, Ann E. Watkins, and Jeffrey A. Witmer. "An Activity-Based Statistics Course."

Summary: Active learning implemented in the stats course to improve student's learning and attitude of the course. Activities were problem based learning with real life situations implemented with the introductory concepts. Authors give cautions and encouragement for instructors to implement the learning activities with student response to the activities.

- **Work Cited:** Jordan, Joy. "The Application of Statistics Education Research in My Classroom."

Summary: Computer lab sessions with real life case studies that pushed the student's cognitive thinking. Measured student feedback with a knowledge survey, and discussed results with students and reviewed as needed. Suggested making small changes by looking outside statistics education and collaborate with other disciplines.

- **Work Cited:** Eckert, Stephen. "Teaching Hypothesis Testing With Playing Cards: A Demonstration."

Summary: After several attempts at getting students to understand hypothesis testing Eckert created a hands on lesson using a deck of cards to teach hypothesis testing. Lesson was not clearly hypothesis testing, but conveyed enough of the idea that students were able to grasp the overall concept.

- **Work Cited:** Garfield, Joan. "Teaching Statistics Using Small-Group Cooperative Learning."

Summary: Corporative learning groups (small groups to maximize individual learning) by structuring activities to allow group learning. Tips for implementing group work; guideline rules for students, how groups should be arranged, informing students of how to best complete the activity, and assessing student learning.

- **Work Cited:** Friedman, Hershey H., Linda W. Friedman, and Taiwo Amoo. "Using Humor in the Introductory Statistics Course."

Summary: Humor in the classroom making the subject more interesting, information recall, reduces stress, and students more alert. Include humor by changing names of companies in the story problems, and telling jokes after the students learned the concept.

- **Work Cited:** Zacharopoulou, Hrissoula. "Two Learning Activities for a Large Introductory Statistics Class."

Summary: How to implement learning activities in a large (300) class. Use of peer teaching, hands-on activity conducted in 2 stages with CLT.

- **Work Cited:** Roiter, Katrina, and Peter Petocz. "Introductory Statistics Courses--A New Way of Thinking."

Summary: A new approach to teaching introductory statistics that is different from probability-driven and data-driven traditional approach. Began with goals and objectives that the course would meet.

- **Work Cited:** Tudor, Gail E. "Teaching Introductory Statistics Online – Satisfying the Students."

Summary: Components of an online course using Blackboard. Lessons had objectives, assigned reading, problems and activities. Implemented discussions, quality influenced by the topic and questions – students all over the world participating. Notes with each lesson.

- **Work Cited:** Adolph, Stephen C. "Is a basketball free-throw sequence nonrandom? A group exercise for undergraduate statistics students."

Summary: Hands on activity with probability and sequences of making free throws. Promotes different statistical approaches. Exercise in data collection, randomization, inference, hypothesis testing, independence.

- **Work Cited:** Rumsey, Deborah J. "Statistical Literacy as a Goal for Introductory Statistics Courses."

Summary: What is statistical literacy? Rumsey said "we want our students to be good "statistical citizens," understanding statistics well enough to be able to consume the information that they are inundated with on a daily basis, think critically about it, and make good decisions based on that information." Promote scientific method in the students. Statistical competence: understanding of data, basic concepts, basic interpretation and communication skills. Students find real world examples more credible – make learning statistics interesting to the students. Gives example of misconceptions of what students and teachers think. Formulas and calculations should not be the focal point of student knowledge, motivate how with why, replace technicalities with more real life plain definitions. Collaborative groups allow students to digest and explore the concepts. Have students develop questions that can be answered with statistics. Communication with others -- give students an opportunity to express what they know through real life experiences

- **Work Cited:** Vaughan, Timothy S. "Teaching Statistical Concepts With Student-Specific Datasets."

Summary: student generated datasets that can be used throughout the term, summary statistics, hypothesis testing, confidence intervals – emailed in homework – done in Excel – students had positive response to the idea

- **Work Cited:** Howley, Peter P. "Keeping it real, keeping them interested and keeping it in their minds."

Summary: Keep everything in context to keep student interest and information that they will retain. Let students use what they already know. Ask questions and get student response as a class. Give scenarios that are real life for the students to apply to stats – showed student improvement

- **Work Cited:** Shoemaker, Allen L. "What's Normal? -- Temperature, Gender, and Heart Rate."

Summary: Pick a data set that interests students and they understand it/relate to it – body temperature.

Appendix D – Objectives for the Introduction to Statistics Course

Intro to Statistics (Stat 1040) Learning Objectives by Chapter (*Statistics Fourth Edition* by D. Freedman, R. Pisani, and R. Purves)

Chapter	Title	Objectives
	Introduction	Course Overview and Background <ul style="list-style-type: none"> • What is statistics? • Why take statistics?
1	Controlled Experiments	1. Understand the importance of the following components in experimental design: <ul style="list-style-type: none"> • Comparison (treatment & control groups) • Randomization • Double-blind • Confounding factors 2. Understand the term “controlled” as a distinguishing feature of an experiment.
2	Observational Studies	1. Distinguish between an observational study and a controlled experiment. 2. Recognize when causation can and cannot be established. 3. Distinguish between causation and association. 4. Understand <i>why</i> observational studies are used. 5. Identify confounding factors and understand their effect. 6. Understand the limitations of both controlled experiments and observational studies.
3	The Histogram	1. Construct a histogram from binned data. 2. Interpret a histogram. 3. Use a histogram to find or approximate percentiles. 4. Distinguish among qualitative, quantitative, discrete and continuous variables.
4	The Average and the Standard Deviation	1. Compute an average. 2. Compute a median. 3. Compute the standard deviation. 4. Recognize the advantages of each measure. 5. Interpret the standard deviation. 6. Find the standard deviation using a calculator.

5	The Normal Approximation for Data	<ol style="list-style-type: none"> 1. Recognize the normal curve as a smoothed histogram. 2. Understand the following points about the normal curve (std normal curve): <ol style="list-style-type: none"> a. symmetric about average/mean (0) b. total area under curve is 100%. c. Any normal curve can be standardized. 3. Find standard units. 4. Understand that standard units indicate how many SDs a value is from the average/mean. 5. Use the normal curve to approximate the % of data in a given interval, when the data are normal. 6. Use the normal curve to find percentiles, when the data are normal. 7. Understand the effect on the average/mean and SD of a list of adding a constant to or multiplying a constant by each number in the list.
6	Measurement Error	<ol style="list-style-type: none"> 1. Recognize the sources of error: bias, chance error. 2. Distinguish between bias and chance error. 3. Identify the likely size of the chance error. 4. Recognize the influence of outliers.
8	Correlation	<ol style="list-style-type: none"> 1. Represent the relationship between two variables with a scatter diagram. 2. Understand what is meant by <i>linear association</i>. 3. Summarize the relationship between two variables with the average/means, SDs, and the correlation coefficient. 4. Given a plot, estimate the correlation coefficient, SD, average/mean, median, mode. 5. Interpret the correlation coefficient. 6. Understand the SD line.
9	More about Correlation	<ol style="list-style-type: none"> 1. Recognize that the correlation coefficient is a <i>pure</i> number. Understand what this means. 2. Understand the relationship between the correlation coefficient and the SD, and plot the relationship. 3. Know when the correlation coefficient can be misleading: <ul style="list-style-type: none"> • non-linear association • outliers • ecological correlations. 4. Distinguish between correlation and causation.
10	Regression	<ol style="list-style-type: none"> 1. Understand the function of the regression line. 2. Use the regression method to make predictions. 3. Understand what is meant by <i>the regression effect</i>. 4. Recognize the regression fallacy. 5. Sketch the regression line.
11	The R.M.S. Error for Regression	<ol style="list-style-type: none"> 1. Understand the term <i>residual</i>. 2. Estimate the r.m.s. error from a plot. 3. Compute the r.m.s. error. 4. Interpret the r.m.s. error. 5. Understand when regression is not appropriate.

12	The Regression Line	<ol style="list-style-type: none"> 1. Understand why the <i>least-squares</i> line is used for regression. 2. Find the equation of a regression line in slope-intercept form. 3. Use a regression line to make predictions. 4. Understand the limitation of the regression line.
13	What are the Chances?	<p>Understand the following concepts and use these to compute chances:</p> <ol style="list-style-type: none"> 1. Definition of chance (long term freq.) 2. Rules of chance <ol style="list-style-type: none"> a. Chances are between 0% and 100% b. $P(A) = 1 - P(A^c)$. 3. Conditional chance versus unconditional chance. 4. Multiplication Rule 5. Independence and the multiplication rule for independence.
14	More about Chance	<ol style="list-style-type: none"> 1. Find chances by listing the ways. 2. Recognize mutually exclusive outcomes 3. Use the addition rule to compute probabilities for mutually exclusive outcomes.
16	The Law of Averages	<ol style="list-style-type: none"> 1. Understand the Law of Averages in terms of counts and percentages. 2. Create a box model for a chance process.
17	The Expected Value and Standard Error	<ol style="list-style-type: none"> 1. Identify the <i>observed value</i>. 2. Compute an expected value for a sum. 3. Interpret an expected value for a sum. 4. Compute a standard error for a sum. 5. Interpret the standard error for a sum. 6. Use the shortcut method to compute SDs. 7. Create a box model for classification and counting. 8. Use the normal curve to approximate the chances for the sum of draws from a box.
18	The Normal Approximation for Probability Histograms	<ol style="list-style-type: none"> 1. Recognize that an empirical histogram converges to a probability histogram. 2. Interpret a probability histogram. 3. Understand the central limit theorem. 4. Summarize a probability histogram with the expected value and standard error. 5. Use the normal curve to approximate the chances.
19	Sample Surveys	<ol style="list-style-type: none"> 1. Understand the following terms: <ol style="list-style-type: none"> a. Population b. Sample c. Parameter d. Statistic e. Probability methods for sampling f. Simple random sample g. Cluster sample h. Sample of convenience 2. Identify sources of bias in sampling methods. 3. Identify effective sampling procedures.

20	Chance Errors in Sampling	<ol style="list-style-type: none"> 1. Compute and interpret EV for percentage. 2. Compute and interpret SE for percentage. 3. Recognize that absolute (not relative) size of the sample is what matters for accuracy. 4. Understand how the normal distribution relates to errors in sampling.
21	The Accuracy of Percentages	<ol style="list-style-type: none"> 1. Use a sample percentage to estimate a population percentage. 2. Use the bootstrap method to estimate SDs for 0-1 boxes. 3. Create a confidence interval for population percentage. 4. Interpret a confidence interval for population percentage. 5. Recognize that formulas are for SRSs only.
23	The Accuracy of Averages	<ol style="list-style-type: none"> 1. Compute and interpret SE for averages. 2. Compute and interpret EV for averages. 3. Compute and interpret the confidence interval. 4. Understand how the confidence interval relates to the normal distribution.
26	Tests of Significance	<ol style="list-style-type: none"> 1. Understand and identify/compute the following: <ol style="list-style-type: none"> a. test of significance b. null hypothesis c. alternative hypothesis d. test statistic e. observed significance level f. p-value g. statistically significant h. degrees of freedom i. student's curve 2. Use the SD+ to estimate the population SD. 3. Determine when to use a t-test and when to use a z-test. 4. Carry out tests of significance.
27	More Test for Averages	<ol style="list-style-type: none"> 1. Carry out a test of significance to compare two averages. 2. Understand that the standard error formula applies to independent samples only.
28	The Chi-Square Test	<ol style="list-style-type: none"> 1. Carry out a chi-square test for multiple categories. 2. Carry out a chi-square test for independence.
29	A Closer Look at Tests of Significance	<p>Understand the following concepts:</p> <ol style="list-style-type: none"> 1. Arbitrariness of significance. 2. Difference between statistical and practical significance. 3. Statistically significant results can still be due to chance. 4. One and two tailed tests. 5. Tests of significance are not relevant when data are available for the entire population. 6. No chance model => no test of significance.

Appendix E – Example of the Instructor Version of the Guided Notes

Notes From: Freedman, D., Pisani, R., & Purves, R. (1998). *Statistics Fourth Edition*. New York, NY: W. W. Norton & Company. Pg. 501-522.

Part 8 – Tests of Significance Chapter 27– More Tests of Averages

Introduction

Suppose we want to determine whether there is a difference in the average flying distance of paper airplanes made with 2 different designs. We create 10 airplanes of each design, fly them and record the distance they travel. We then compute the average for each design (sample).

The null hypothesis is that there is no difference in the average distance the planes fly for the two designs:

**NULL HYPOTHESIS: AVERAGE OF SAMPLE 1 = AVERAGE OF SAMPLE 2
(OR AVERAGE OF SAMPLE 1 – AVERAGE OF SAMPLE 2 = 0).**

The test statistic has the usual form: $z = \frac{OV_{diff} - EV}{SE_{diff}}$, where ‘OV’ is the observed value of the difference in the sample averages (average 1 – average 2) and ‘EV’ is the expected value of the difference in the sample averages (usually 0).

The Standard Error for a Difference

When comparing two sample averages, the SE for the difference between their averages is needed.

EV_{diff} = **THE EXPECTED DIFFERENCE UNDER THE NULL HYPOTHESIS – THIS IS USUALLY ZERO, I.E. THERE IS NO DIFFERENCE.**

The standard error for the difference of two *independent* quantities is:

$$SE_{diff} = \sqrt{a^2 + b^2}$$

where a is the SE for the first quantity and b is the SE for the second quantity. This is sometimes called “the square root law”.

These formulas can be used for averages, sums, or percentages. (If the average is picked – use the average through the whole problem)

Samples Must Be Independent

Example A: 100 draws are made at random with replacement from the box:

1	2	3	4	5
---	---	---	---	---

The expected number of 1s is 20 with an SE of 4. The expected number of 5s is also 20 with an SE of 4. Can the square root law be applied to find the SE for the difference between the number of 1s and the number of 5s?

The SE for the difference cannot be used here because the draws are coming from the same box.

Example B: One hundred draws are made randomly with replacement from the box:

1	2
---	---

Independently, 100 draws are made at random with replacement from the box:

3	4
---	---

If possible, find the EV and the SE for the difference between the number of 2's drawn from the first box and the number of 3's drawn from the second.

1 2 EV FOR 2'S IS 50 AND $SE = \sqrt{100} \times \sqrt{.5 \times .5} = 5$

3 4 EV FOR 3'S IS 50 AND $SE = \sqrt{100} \times \sqrt{.5 \times .5} = 5$

SO THE $SE_{diff} = \sqrt{5^2 + 5^2} = 7.07$

Example C: A middle school P.E. teacher wants to know if more of his students can run 1 mile in under 10 minutes or 2 miles in under 25 minutes. He times the students on the two distances (on two different days) and finds that 45% can run 1 mile in under 10 minutes while 67% can run 2 miles in under 25 minutes. Can we use the square root law to find the standard error of the difference for these data?

NO WE CANNOT USE THE SQUARE ROOT LAW BECAUSE THEY SAMPLES ARE NOT INDEPENDENT — THE SAME STUDENTS ARE BEING TESTED. SPEED RUNNING 2 MILES DEPENDS ON IF YOU CAN RUN A MILE.

Example D: We'd like to assess the effect of piano lessons on spatial-temporal reasoning by comparing the average change in reasoning score of pre-kindergarteners who received piano lessons for 6 months to the average change in reasoning score of a control group that did not receive piano lessons. There were 34 students in the piano lesson group. The average score was 3.62 with an SD of 3.06. There were 44 students in the control group. The average score for this group was 0.39 with and SD of 2.42.

NULL: THERE IS NO DIFFERENCE IN THE TREATMENT AND CONTROL GROUP.

ALTERNATIVE: THE DIFFERENCE BETWEEN THE 2 GROUPS IS REAL.

SAMPLE A — TREATMENT GROUP EV = 3.62 AND $SE_{ave} = \frac{\sqrt{34} \times 3.06}{34} = 0.52$

SAMPLE B — CONTROL GROUP EV = 0.39 AND $SE_{ave} = \frac{\sqrt{44} \times 2.42}{44} = 0.36$

$SE_{diff} = \sqrt{(0.52)^2 + (0.36)^2} = 0.63$

$EV_{diff} = 3.62 - 0.39 = 3.23$ FROM THIS WE FIND THE Z TEST STATISTIC: $z = \frac{3.23 - 0}{0.63} =$

5.1 P-VALUE IS 0%

CONCLUSION: FAIL TO ACCEPT THE NULL, THE DIFFERENCE IS REAL, SOMETHING IS DIFFERENT BETWEEN THE TREATMENT AND CONTROL GROUP.

Example E: In a randomized, controlled, double-blind study published in the *Journal of the American Medical Association* in October 2007, researchers followed 371 heavy drinkers for 14 weeks to try to determine whether the migraine drug Topamax could help them to quit drinking. By the end of the study, 27 of the 183 people in the Topamax group had quit drinking completely, while only 6 of the 188 people in the placebo group had quit drinking completely. Is this evidence that there is a difference between the placebo group and Topamax group? Clearly state the null and alternative hypotheses, calculate the appropriate test statistic, find the p-value, and state your conclusions.

SOLUTION: THIS IS A 2-SAMPLE, 2-SIDED Z-TEST BECAUSE WE JUST WANT TO KNOW IF THERE IS A DIFFERENCE BETWEEN THE 2 GROUPS.

NULL: TOPAMAX AND THE PLACEBO HELP DRINKING AT THE SAME RATE, THERE IS NO DIFFERENCE BETWEEN THE TWO GROUPS.

ALTERNATIVE: THERE IS A DIFFERENCE BETWEEN THE TOPAMAX AND PLACEBO GROUPS, THERE IS A DIFFERENCE IN THE QUIT DRINKING RATE.

TOPAMAX:

SAMPLE SIZE = 183

SAMPLE % QUIT = $\frac{27}{183} = 14.75\%$

$$SD_{\text{Topamax}} = \sqrt{0.1475 \times 0.8525} = 0.355$$

$$SE_{\%-\text{Top}} = \frac{\sqrt{183 \times 0.355}}{183} \times 100\% = 2.62\%$$

PLACEBO GROUP:

SAMPLE SIZE = 188

SAMPLE % QUIT = $\frac{6}{188} = 3.19\%$

$$SD_{\text{placebo}} = \sqrt{0.0319 \times 0.9681} = 0.176$$

$$SE_{\%-\text{plac}} = \frac{\sqrt{188 \times 0.176}}{188} \times 100\% = 1.28\%$$

$$SE_{\text{diff}} = \sqrt{(2.62\%)^2 + (1.28\%)^2} = 2.92\%, z = \frac{14.75\% - 3.19\%}{2.92\%} = 3.96$$

P-VALUE (2 TAILED BECAUSE WE ARE JUST TESTING FOR A DIFFERENCE, NOT THAT THE TOPAMAX IS BETTER THAN THE PLACEBO - IT WOULD BE ONE-TAILED IF WE WERE TESTING THAT THE TOPAMAX WAS BETTER THAN THE PLACEBO) = $(100\% - 99.999\%) \approx 0\%$

CONCLUSION: REJECT THE NULL, THE RESULT IS HIGHLY STATISTICALLY SIGNIFICANT, THERE IS A DIFFERENCE BETWEEN THE TOPAMAX AND PLACEBO GROUP, IT APPEARS THAT THE TOPAMAX HELPS PEOPLE TO QUIT DRINKING AT A HIGHER RATE.

Qualitative Responses

Two sample procedures can also be used to address qualitative (non-numeric) issues.

Example F: A large company is interested in comparing whether the employees in 'sales' or 'management' are happier with their jobs. A random sample of 75 sales employees is conducted and it is found that 88% of these are 'happy with their jobs'. Then a random sample of 75 management employees and it is found that 91% of these are 'happy with their jobs'. Is there evidence of a difference between the two groups?

NULL: THERE IS NO DIFFERENCE IN THE JOB HAPPINESS BETWEEN SALES AND MANAGEMENT.

ALTERNATIVE: THE DIFFERENCE BETWEEN THE 2 GROUPS IS REAL, ONE GROUP IS HAPPIER THAN THE OTHER.

SAMPLE A - TREATMENT GROUP EV = 88% AND $SE_{\%} = \left(\frac{\sqrt{75 \times \sqrt{.88 \times .12}}}{75} \right) \times 100 = 3.7\%$

SAMPLE B - CONTROL GROUP EV = 91% AND $SE_{\%} = \left(\frac{\sqrt{75 \times \sqrt{.91 \times .09}}}{75} \right) \times 100 = 3.3\%$

$$SE_{\text{diff}} = \sqrt{(3.7)^2 + (3.3)^2} = 4.95 \quad EV_{\text{diff}} = 91 - 88 = 3 \quad \text{FROM THIS WE FIND THE Z TEST}$$

STATISTIC: $z = \frac{3-0}{4.95} = 0.6$ P-VALUE IS $100 - 45.5 = 54.5$ SO THE ONE SIDE IS $(54.5/2) =$

27.25% CONCLUSION: ACCEPT THE NULL, THE DIFFERENCE IS DUE TO CHANCE.

Appendix F – Example of the Student Version of the Guided Notes

Notes From: Freedman, D., Pisani, R., & Purves, R. (1998). *Statistics Fourth Edition*. New York, NY: W. W. Norton & Company. Pg. 501-522.

Part 8 – Tests of Significance
Chapter 27– More Tests of Averages

Introduction

Suppose we want to determine whether there is a difference in the average flying distance of paper airplanes made with 2 different designs. We create 10 airplanes of each design, fly them and record the distance they travel. We then compute the average for each design (sample).

The null hypothesis is that there is no difference in the average distance the planes fly for the two designs:

Null hypothesis:

The test statistic has the usual form: $z = \frac{OV_{diff} - EV}{SE_{diff}}$, where 'OV' is the observed value of the difference in the sample averages (average 1 – average 2) and 'EV' is the expected value of the difference in the sample averages (usually 0).

The Standard Error for a Difference

When comparing two sample averages, the SE for the difference between their averages is needed.

EV_{diff} = the expected difference under the null hypothesis – this is usually zero, i.e. there is no difference.

The standard error for the difference of two *independent* quantities is:

$$SE_{diff} = \sqrt{a^2 + b^2}$$

where a is the SE for the first quantity and b is the SE for the second quantity. This is sometimes called "the square root law".

These formulas can be used for averages, sums, or percentages.

Samples Must Be Independent for the SE_{diff} Method

Example A: 100 draws are made at random with replacement from the box:

1	2	3	4	5
---	---	---	---	---

The expected number of 1s is 20 with an SE of 4. The expected number of 5s is also 20 with an SE of 4. Can the square root law be applied to find the SE for the difference between the number of 1s and the number of 5s?

Example B: One hundred draws are made randomly with replacement from the box:

1	2
---	---

Independently, 100 draws are made at random with replacement from the box:

3	4
---	---

If possible, find the EV and the SE for the difference between the number of 2's drawn from the first box and the number of 3's drawn from the second.

Example C: A middle school P.E. teacher wants to know if more of his students can run 1 mile in under 10 minutes or 2 miles in under 25 minutes. He times the students on the two distances (on two different days) and finds that 45% can run 1 mile in under 10 minutes while 67% can run 2 miles in under 25 minutes. Can we use the square root law to find the standard error of the difference for these data?

Example D: We'd like to assess the effect of piano lessons on spatial-temporal reasoning by comparing the average change in reasoning score of pre-kindergarteners who received piano lessons for 6 months to the average change in reasoning score of a control group that did not receive piano lessons. There were 34 students in the piano lesson group. The average score was 3.62 with an SD of 3.06. There were 44 students in the control group. The average score for this group was 0.39 with and SD of 2.42.

Example E: In a randomized, controlled, double-blind study published in the *Journal of the American Medical Association* in October 2007, researchers followed 371 heavy drinkers for 14 weeks to try to determine whether the migraine drug Topamax could help them to quit drinking. By the end of the study, 27 of the 183 people in the Topamax group had quit drinking completely, while only 6 of the 188 people in the placebo group had quit drinking completely. Is this evidence that there is a difference between the placebo group and Topamax group? Clearly state the null and alternative hypotheses, calculate the appropriate test statistic, find the p-value, and state your conclusions.

Qualitative Responses

Two sample procedures can also be used to address qualitative (non-numeric) issues.

Example F: A large company is interested in comparing whether the employees in 'sales' or 'management' are happier with their jobs. A random sample of 75 sales employees is conducted and it is found that 88% of these are 'happy with their jobs'. Then a random sample of 75 management employees and it is found that 91% of these are 'happy with their jobs'. Is there evidence of a difference between the two groups?

Appendix G – Example of the Instructor Guide for an Article Example**Industry Bias*****Instructor Guide***

Title: Industry money may bias drink studies

Topic: Bias

Objective(s): 6.1 Recognize the sources of error: bias, chance error
6.2 Distinguish between bias and chance error

Citation: By MARILYNN MARCHIONE, The Associated Press, Monday, January 8, 2007 found at: <http://www.washingtonpost.com/wp-dyn/content/article/2007/01/08/AR2007010800750.html>

Article Summary:

Many studies are conducted to see what types of drinks help various health problems, but the conclusions differ depend on who, the drink industry or a research lab, funds the study.

“Biased science can affect consumer behavior, doctor recommendations and even federal regulation of marketing claims for such products, [Dr. David] Ludwig [an obesity specialist at Children's Hospital Boston] said.”

...

“They used Medline, a compendium of scientific literature, to identify 538 studies about soda, milk or juice involving people, not animals. . . .”

“Of the 206 studies, only 111 gave information on funding: 22 percent were fully funded by industry and 32 percent got some industry money.”

...

“For example, a negative finding about soda would harm a soda sponsor but could help a dairy producer.”

Questions:

1. How may the industry money bias the results of the 111 studies?
2. What implications may this bias have on society?

Mini-Lesson Plan: Give the students the snippet from the article, and have them answer the questions in the Article Guide.

Appendix H – Example of the Student Guide for an Article Example**“Industry money may bias drink studies”**

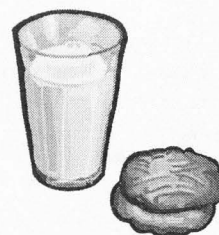
Read the article, “Industry money may bias drink studies”, by Marilyn Marchione, found at: <http://www.washingtonpost.com/wp-dyn/content/article/2007/01/08/AR2007010800750.html>. Then answer the following questions.

1. How may the industry money bias the results of the 111 studies?

2. How is the bias discussed in the article different from the measurement bias discussed in class? How are they similar?

3. What implications may bias have on society?

4. **Hypothetical:** The Nabisco Company is helping fund a study on the best time of day to drink milk which yields the highest calcium absorption. The study concludes that drinking milk right before bed yields the highest calcium absorption. How might the Nabisco Company use this study to advertise their Oreo cookie? In what ways would bias play a role in the Oreo cookie advertising strategy?



Appendix I – Example of the Instructor Guide for an Applet Activity Example

Law of Averages Applet/In-Class Experiment

Objective: Student will experience firsthand the law of averages. Students will also discover the difference between observed and expected values.

Use the Experiment for: In-class activity/Experiment, Homework, Stimulating a class discussion during the lecture.

Experiment: This experiment can be conducted using pennies of the following applet:
(<http://www.math.usu.edu/~schneit/CTIS/CoinFlipper/index.html>)

Directions:

- Have the students fill in the Expected count and the Expected % -- remind them of probability – then run the applet (or flip the coins).
- Then have the students flip individually 10 times and compare around the class how many heads were observed.
- Instruct the students to work in pairs to find the 50 and 150 flips.
- After completing the coin flipping have the students calculate the percentages of each flip.
- Then present the following questions (Discuss in-class if part of a lecture, assign as part of the homework, or have the students discuss in pairs if activity is used as an in-class experiment.)

1. What causes the trends between the observed and the expected number of coin flips?

Solution: as the number of tosses increases the closer to the expected percentage the observed number of tosses will become.

2. In your own words describe the Law of Averages.

Solution: The chance error from repeating the same tossing/drawing process will be a small percentage of the actual number of items tossed/drawn.

Tally Sheet:

Observed 'heads' count

Heads	10 tosses	50 tosses	150 tosses
Observed count	Heads	Heads	Heads
Expected count	Heads	Heads	Heads
Difference	Heads	Heads	Heads

Percentage 'heads'

Heads	10 tosses	50 tosses	150 tosses
Observed percentage	%	%	%
Expected percentage	%	%	%
Difference	%	%	%

Appendix J – Example of the Student Guide for an Applet Activity Example**Law of Averages Experiment**

Name: _____

Directions: This experiment can be conducted using pennies or the following applet:

<http://www.math.usu.edu/~schneit/CTIS/CoinFlipper/index.html>

- Determine with a fair coin what the expected count of heads in each number of tosses and the expected percentage of heads.
- Run the applet (or flip the coins).
- After completing the coin flipping calculate the percentages of each flip.
- Answer the following questions below the tally sheet.

Tally Sheet:

Observed 'heads' count

Heads	10 tosses	50 tosses	150 tosses
Observed count	Heads	Heads	Heads
Expected count	Heads	Heads	Heads
Difference	Heads	Heads	Heads

Percentage 'heads'

Heads	10 tosses	50 tosses	150 tosses
Observed percentage	%	%	%
Expected percentage	%	%	%
Difference	%	%	%

1. What do you notice as the number of tosses increases?
2. What causes the trends between the observed and the expected number of coin flips?
3. In your own words describe the Law of Averages.

Appendix K – Correlation Applet

Found at: <http://www.math.usu.edu/~schneit/CTIS/CorrelationGame/index.html>

The Correlation Game - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.math.usu.edu/~schneit/CTIS/CorrelationGame/index.html

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The Correlation Game

musicals	body	wagons	students
6	6	6	6
12	12	12	12
18	18	18	18

Points: Team 1 Team 2 Team 3

0 0 0

The Correlation Game

Instructions

Overview: Teams compete to guess correlations from displayed graphs.

The Game Board: The game board displays 3 tiles in each of 4 different categories: health, car, NFL, and Miscellaneous. One tile in each category is worth 6 points, one is worth 12, and one is worth 18. The point values are displayed on the tiles. When a tile is selected, the applet displays a plot showing data relevant to associated category.

To Play: A team is chosen to go first. The team selects any tile from the game panel. When the tile is selected, a plot is displayed. Each team makes a guess at the correlation. The team with the closest guess wins the points. In the event of a tie, the points are divided among the tying teams. When all tiles have been chosen, the team with the most points wins.

The Correlation Game - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://www.math.usu.edu/~schneit/CTIS/CorrelationGame/index.html

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The Correlation Game

Guess: Team 1 Team 2 Team 3

$r = 0$ $r = 0$ $r = 0$ enter

The Correlation Game

Instructions

Overview: Teams compete to guess correlations from displayed graphs.

The Game Board: The game board displays 3 tiles in each of 4 different categories: health, car, NFL, and Miscellaneous. One tile in each category is worth 6 points, one is worth 12, and one is worth 18. The point values are displayed on the tiles. When a tile is selected, the applet displays a plot showing data relevant to associated category.

To Play: A team is chosen to go first. The team selects any tile from the game panel. When the tile is selected, a plot is displayed. Each team makes a guess at the correlation. The team with the closest guess wins the points. In the event of a tie, the points are divided among the tying teams. When all tiles have been chosen, the team with the most points wins.

Appendix L – Olympic Excel Assignment

Name:

Directions: The following data is from the 2008 Summer Olympic Games. Examine the data and then answer the questions.

Country (# participating)	# participating	Medals Won
Netherlands Antilles (3)	3	0
Afghanistan (4)	4	1
Albania (11)	11	0
Algeria (62)	62	1
American Samoa (5)	5	0
Andorra (5)	5	0
Angola (32)	32	0
Antigua and Barbuda (5)	5	0
Argentina (137)	137	6
Armenia (25)	25	6
Aruba (2)	2	0
Australia (433)	433	46
Austria (72)	72	3
Azerbaijan (39)	39	7
Bahamas (19)	19	2
Bahrain (15)	15	1
Bangladesh (5)	5	0
Barbados (6)	6	0
Belarus (181)	181	19
Belgium (96)	96	2
Belize (3)	3	0
Benin (5)	5	0
Bermuda (6)	6	0
Bhutan (2)	2	0
Bolivia (6)	6	0
Bosnia and Herzegovina (5)	5	0
Botswana (12)	12	0
Brazil (277)	277	15
British Virgin Islands (2)	2	0
Bulgaria (72)	72	5
Burkina Faso (2)	2	0
Burundi (3)	3	0
Cambodia (4)	4	0

- 1 Find the average and sd for the number participating and the total medals won:

Average #	Average Medals
SD #	SD medals

- 2 Find the correlation between the number from the country participating in the olympic games and then total medals the country won.

$r =$

- 3 What does this correlation coefficient tell you about the data?

Answer:

- 4 Sort the data, and create a scatter plot, including a title and labels. What information can you gather from the scatter plot? Also does the scatter plot accurately represent the correlation coefficient?

Answer:

Scatter Plot:

- 5 What happens to the r value and scatter plot (with a title and labels) if the countries who won 0 medals are not included? (find r and make another scatter plot)

Answer:

Scatter Plot:

Cameroon (33)	33	1
Canada (332)	332	18
Cape Verde (3)	3	0
Cayman Islands (4)	4	0
Central African Republic (3)	3	0
Chad (2)	2	0
Chile (27)	27	1
China (639)	639	100
Chinese Taipei (80)	80	4
Colombia (64)	64	2
Comoros (3)	3	0
Congo (3)	3	0
Cook Islands (4)	4	0
Costa Rica (8)	8	0
Côte d'Ivoire (20)	20	0
Croatia (105)	105	5
Cuba (149)	149	24
Cyprus (17)	17	0
Czech Republic (134)	134	6
Denmark (84)	84	7
Djibouti (2)	2	0
Dominica (1)	1	0
Dominican Republic (25)	25	2
DR Congo (5)	5	0
Ecuador (25)	25	1
Egypt (103)	103	1
El Salvador (11)	11	0
Equatorial Guinea (3)	3	0
Eritrea (9)	9	0
Estonia (47)	47	2
Ethiopia (22)	22	7
Fiji (6)	6	0
Finland (58)	58	4
France (323)	323	40
FS Micronesia (15)	15	0
FYR Macedonia (7)	7	0
Gabon (4)	4	0
Gambia (3)	3	0

...

(Data truncated for space reasons)data from: http://en.wikipedia.org/wiki/2008_olympics and<http://results.beijing2008.cn/WRM/ENG/INF/GL/95A/GL0000000.shtml>

- 6 What is the difference between the r values?
How could they be interpreted?

Answer:

- 7 What was your favorite sport in the 2008 olympics to watch?

Answer:

- What did you learn from/ think of this assignment?

Answer:

Appendix M – Measuring Activity

Activity: Measure the Error

Objective: Students will be able to interpret and understand how error is incorporated into measuring, and understand how to account for the error.

Supplies: Several of the same objects that are easily measured (i.e. length of text book trash can, computer screen, baking sheet, licorice, etc), several measuring devices – one for each object (i.e. measuring tape, small ruler, yard stick, paper ruler, yarn, etc.), and a record sheet (student and white board is sufficient)

Activity Guide

Instructions: Have the students break up into small groups and have each student measure the object with one measuring device, and record the measurements for the class to see (this should produce 20-30 measurements).

Object to be measured: Width of the table top.

Measuring Devices (suggestions, but not limited too):

Small ruler

Forearm

Measuring tape

Yard Stick

3 × 5 note card

Strip of graph paper with blocks on it

Give each row of Students a measuring device.

Before instructing the students to measure the table – have them hypothesize what they think the outcome will be in terms of how many of the students will get the same measurement. Then have each student measure the width of the table with the device. Instruct one student to record all of the lengths for the group.

After each measurement has been recorded have the students answer the following questions as a group. What would be the best way to describe all of the measurements that the group recorded? How would you be able to account for the differences/variation found between the measurements? This should motivate the students to find an average the measurements and the SD.

Conduct a class discussion about whether they should accept or reject the hypothesis that they came up with for the activity. Then have a discussion explaining to the class that the SD of all the measurements is the likely size of the chance error in a single measurement.

Appendix N – Tootsie Pop Activity

Applet – How does your Tootsie Pop? Animated Confidence Interval Applet

Objective: Students will understand what a confidence interval represents in terms of the sampling a real data scenario.

Applet Address: <http://www.stat.tamu.edu/~west/applets/ci.html>

Supplies: Projector, Screen, Computer with internet connection, handout for each student, white/chalk board, markers/chalk, Tootsie Pops for each student (optional)

Motivation: Often students need to “play with” a concept before they grasp the meaning of it. This applet allows the student to look at confidence intervals with a visual representation.

NOTE: Do NOT use real Tootsie Pops in this activity if you have students who are allergic to Soy or Milk, as they are contained in the sucker; for more information about the product visit <http://www.tootsie.com/health.php?pid=168>.

Instructions: Before using this applet introduce students to confidence intervals and how to compute them. (if you want to use real life data distribute the Tootsie Pops to the class the day before the activity and have them count the number of licks until they taste the chocolate center. As a class decide which part of the sucker will be licked over and over again – it is recommended to just plainly lick the side of the Pop – this is important for maintain experimental consistency.

After teaching the fundamentals of confidence intervals (and maybe collecting the number of licks from each person), write the following question on the board, “What do confidence intervals represent in terms of real data?” Also on the board write the following:

Fill in the underlined parts with the class

Subject: Licks to the center of a Tootsie Pop
 What/Who makes up the Sample: Consumers of 1 bag of Tootsie Pops
 Sample μ : 300 (or find the mean of the class data, Excel works well in a live situation)
 Sample σ : 80 (or find the SD of the class data, Excel works well in a live situation)

Before beginning the activity pass out the following handout to the class (and Tootsie Pops), instruction the students to only fill out the left side of the task sheet. Give the students 5-8 minutes to fill in the left side of the worksheet with a partner.

Pass out the Tootsie Pops to the class (or show the following site:

<http://www.tootsie.com/products.php?pid=168>) and ask the students if they were to create an experiment with Tootsie Pops, what kinds of experiments could they create? Ask for suggestions, waiting until an experiment with the number of licks to the center comes up; fill in Subject on the board. Or if you have the students lick their own Pops, ask the class what they think they could do with the data they found.

Then ask the students who/what makes up the sample in all they have to experiment with is one bag of Tootsie Pops; fill in on the board.

Relate to the student that for the purpose of this applet activity the average number of licks to get the center of the Tootsie Pop has a mean of 300 and a SD of 80. (Sources vary on the actual number of licks one source: <http://gwax.com/content/tootsiepop.html>)

Load the Applet.

1. View the 1st Confidence Interval (CI) at the top of the page.

In a discussion with the students include the following points for the 1st CI:

- Pretend the sample in our experiment has the following CI
- What is the sample mean? (write the mean on the board, label: Our Class)
- How does the sample mean differ from the actual mean of 300?
- Let's pretend that another classroom in New York conducts the same experiment, click SAMPLE. What is the mean of the NY sample? (write the mean on the board, label: NY)
- How does the sample mean differ from the actual mean of 300? How does the NY mean differ from our classes mean?
- In both out class sample and the NY sample is the actual mean still in the CI?

NOTE: If the CI does not include the mean ask the students what may account for the difference.

2. View the 2nd Confidence Interval – Applet option 1

Include the following points/questions in a class discussion:

- If every class room in the state conducted a Tootsie Pop licking experiment, what would the confidence intervals look like? (have a student draw what they think on the board)
CLICK ANIMATE
- Explain how the animation represents several classrooms of students experimenting to see how many licks it takes to get to the center of a Tootsie Pop.
- From this series of confidence intervals, how confident are we that the true mean of the number of licks is in the interval? (it should be 68% if the confidence level was not changed)
- Does this level seem adequate if we had to write a report to the Tootsie Roll Industry about the number of licks it takes to get the middle of their suckers?
- Is there a better confidence level to test at? (Change the confidence level to 95% or 99% and re-test ANIMATE)
- What happens to the CIs when the confidence level is increased?
- Why does the higher confidence level include more of the sample data?

3. View the 4th CI applet at the bottom of the page.

Include the following points/questions in a class discussion:

- Move the confidence level to 68%, or to whatever the 1st level was in #2.
- What does the red part of the graph demonstrate? How confident we are that the true mean is contained in the interval – the larger the confidence interval is the more confident that the true mean is in the interval.
- What happens to the graph as we change the confidence level to 95%? ***** Note the area in the graph is not directly representing the chance of the confidence interval. The larger the interval becomes, the more confident we are that the true mean is in the interval.

After viewing the applet and the class discussion have the students fill out the right side of the handout. Ask students to include the importance of a confidence level, how they would explain a confidence interval in terms of real data, and what a confidence interval represents.

**How does your Tootsie Pop?
Animated Confidence Interval Applet**

Name: _____

Applet Address: <http://www.stat.tamu.edu/~west/applets/ci.html>

What do confidence intervals represent?

Pre-Applet Activity

To find a confidence interval from a sample I
need to know the . . .

- _____
- _____
- _____

The formula for a confidence interval is . . .

In non-statistics terms a confidence interval is . . .

Notes about the Applet:

Post-Applet Activity

Summarize the Tootsie Pop experiment and
include what a confidence interval represents
with the real data. Include what you learned from
the activity about confidence intervals.

Appendix O – Hypothesis Testing Group Activity

t or z, which is it to be?

Objective: Students will recognize which hypothesis test method the z-test or the t-test, for a real life situation.

Prerequisite Knowledge: Students should have an understanding of how to find expected value and standard error, as well as an understanding of hypothesis testing.

Supplies:

- One stick of Starburst candy (sticks of Lifesavers and Smarties would probability work too – as it turns out Starburst have exactly 3 candies of each flavor so there is no statistical significance – Smarties appear to be more random.), contains 12 candies, per group.
- One Ziplock of about 80-100 Mike and Ike candies (about $\frac{1}{2}$ cup) per group.
- One worksheet with a z-table and t-table for each student.

Lesson Plan:

- I. Before beginning the activity review the properties of the z-test and the t-test.

Use the Z test when:

1. The data are like draws from a box.
2. The number of draws is reasonably large, about 25 or more.
3. The SD of the box is known and the contents of the box follow the normal curve (even if the sample size is small).

Use the t-test when:

1. The data are like draws from a box.
2. The number of draws is small (<25 draws).
3. The SD of the box is unknown.
4. The histogram of the contents of the box does not look much different from the normal curve.

- II. Divide the class into groups (this activity can be done also as a entire class with one set of candy)

- III. Relate the following situation to the students:

Your grandmother has a sweet tooth, and not just any normal sweet tooth, but a sweet tooth for lemon flavored chewy candy. Whenever you go to her house in one candy dish there are only cherry, lime, orange, and strawberry Mike and Ike's and in the other candy dish there are only cherry, orange and strawberry Starbursts. You notice the missing lemon candies and ask your grandmother where all of the lemon candies went, she says that she ate them, and is very disappointed because there always seem to be more of the other individual flavors, compared to the lemon flavored candies. Since taking this class you can now help solve your grandmother's lack of lemon candy dilemma. Design an experiment in which you answer the question, are the expected counts of lemon candies in Mike and Ike's and Starburst different from the amount in the packages?

- IV. Have the students create complete the following task sheet in small groups. For a discovery based learning approach, the instructor should only answer questions that pertain to the procedure of the activity to encourage students to critically think about hypothesis testing.

T OR Z, WHICH IS IT TO BE?

Your grandmother has a sweet tooth, and not just any normal sweet tooth, but a sweet tooth for lemon flavored chewy candy. Whenever you go to her house in one candy dish there are only cherry, lime, orange, and strawberry Mike and Ike's and in the other candy dish there are only cherry, orange and strawberry Starbursts. You notice the missing lemon candies and ask your grandmother where all of the lemon candies went, she says that she ate them, and is very disappointed because there always seem to be more of the other individual flavors, compared to the lemon flavored candies. Since taking this class you can now help solve your grandmother's lack of lemon candy dilemma. Design an experiment where you answer the question, is the expected count of lemon candies in Mike and Ike's and Starburst different from the amount in the package?

Question: Is grandma getting shortchanged by the amount of lemon candies in her Mike and Ike package or Starburst package? It is known that Mike and Ike's have 5 flavors (cherry, lime, orange, lemon, and strawberry) and Starburst's have 4 flavors (cherry, lemon, orange, and strawberry)

1. Indicate which test should be used to determine if the number of lemons in a package of Mike and Ike's are equal to the expected number, justify your reasoning.
2. Determine the box model:
3. State the null hypothesis:
4. State the alternative hypothesis:
5. Determine the expected value (EV):
6. Determine the standard error (SE):
7. Calculate the appropriate test statistic:
8. Find the p-value:
9. State your conclusion:

1. Indicate which test should be used to determine if the number of lemons in a package of Mike and Ike's are equal to the expected number, justify your reasoning.
2. Determine the box model:
3. State the null hypothesis:
4. State the alternative hypothesis:
5. Determine the expected value (EV):
6. Determine the standard error (SE):
7. Calculate the appropriate test statistic:
8. Find the p-value:
9. State your conclusion:

Appendix P – Discussion Questions

Day 1 Discussion

Posted Question:

Discuss at least 2 of the following topics:

- How did you feel about the first day of class?
- How do you feel about guided notes?
- Would you prefer to have the notes printed for you and brought to class, or print them off Blackboard yourself?
- What hesitations to you have about the class?
- What are you excited about learning in this class?

Day 2 Discussion

Posted Question:

Histograms are often a difficult concept for students to grasp, are there any concerns you have about histograms (what are you unclear about)?

In constructing the height histogram with the class data, did you find it useful to have real data from the class instead simulated data? What did you think about the height histogram we made as a class at the front of the room? Did it help you visualize what a histogram is in "real life"?

Would you like to see more "real life" data that pertains to you versus data from a book used in lectures?

Day 3 Discussion

Posted Question:

Briefly discuss what you learned in class today. What is at least one way you could include the concepts learned today in your everyday life or profession?

Day 4 Discussion – Ch 5

Posted Question:

In 3 or more sentences summarize what you learned in class today. After thinking about the class meeting, is there anything that is still unclear about how histograms relate the normal distribution?

Day 5 Discussion – Ch 6 & 7

Posted Question:

Explain how the in-class measuring activity helped you understand the concept of measurement error. Also, how did you feel about the activity; was it worthwhile, would you recommend that other Stat 1040 teachers use a group activity like this, etc.?

*** To get the full 3 points: Write 4-5 complete, detailed sentences answering the above questions.

2 points: 2-3 sentences, 1 point: 1 sentence

Day 6 Discussion – Chapter 7 & 8 (a little of 9)

Posted Question:

1. What would you say your level of experience is in using MS Excel, or a similar program?
2. From the review of Experimental Design and Descriptive Statistics today and Tuesday, what topics do you still have questions/are unclear about?

3. As I look ahead to the midterm review, I would like to have a review that aides in your study of the material. Please look at the following choices and tell me why that choice is your preference.

When participating in a midterm review session I prefer that . . .

- a) the teacher provides a sample midterm that we go over as a class.
- b) the instructor creates a list of the material that will potentially be covered on the midterm and then gives example problems.
- c) the review class is an open forum and students just ask questions.
- d) we play a review game as a class in teams.

Day 7 Discussion – Chapter 8 & 9**Posted Question:**

Today we went over several technology "topics" please reflect upon the following:

From the correlation Applets I learned . . .

Which applet did you feel like you understood the concept of correlation from the best?

From the Excel exercise I learned . . .

If I were to use the applets and Excel to tutor another student about correlation I would change . . .

Day 8 Discussion – Chapter 10 & 11**Posted Question:**

Discuss what you think about the homework assignments -- if you like/dislike the applets, articles, book work, etc and why. Do you find the non-book work beneficial to your learning and understanding of the concepts presented in class?

(I will probably ask more questions about this later in the semester)

Day 9 Discussion – Chapter 12**Posted Question:**

Describe how you plan to study for the Midterm coming up on Tuesday September 30th. (2-4 sentences)

Day 12 Probability (Ch 13 & 14)**Posted Question:**

In what ways can you relate the concepts of probability discussed in class to your everyday life?

What games did you play as a child that contained a probability element? Describe the game and the probability element.

Day 13 Discussion – More Probability**Posted Question:**

In a detailed description, please explain how the storybook ("Are you my Mother?") and the candy activities helped you solidify the concept of probability. Include what you learned and what you still have questions about.

Day 14 Discussion – Chapter 16**Posted Question:**

After learning about the law of averages, in what ways have you seen the law of averages apply to your life? (e.g. GPA, miles per gallon consumption, bank accounts, etc. think about something that you have done over and over again that eventually converges to an expected outcome.)

Day 15 Discussion – Chapter 17 EV and SE**Posted Question:**

How does finding the standard units with the expected value and standard error relate to finding the standard units with the average and SD? Please explain your thinking in more than one sentence.

Day 16 Discussion – Chapter 18 – Probability Histograms and Normal Approximation**Posted Question:**

Describe what you learned from the number drawing group activity today. How did this activity enhance your understanding of the concepts presented in class today?

Day 17 Discussion Chapters 19 & 20**Posted Question:**

Briefly summarize what you learned today. Discuss how you thought class went and any concepts you are still unclear about.

Day 19 Discussion Ch 23

Posted Question:

Explain what you learned today from the Tootsie Pop example; include how the applet enhanced your understanding of confidence intervals, how you felt about the real life application, etc.

** An additional, optional discussion topic, include what concepts you would like to see covered in the Midterm Review next week.

Day 23 Discussion Ch 26

Posted Question:

Briefly summarize the components needed to conduct a test of significance. Then discuss a real life application (possibly from your major or another class) of a test of significance. Mention the question being tested and the outcome (if known).

Day 24 – Candy Activity

Posted Question:

What did you think of the Mike and Ike and Starburst group activity today? Include what you learned, how you felt about working in a group, how you felt about hands on learning, and anything else that you feel would help me to improve the activity.

Thanks!

Day 25 – Chi-Square Test

Posted Question:

Describe what you learned about the chi-square test today. What did you find interesting about the test and it's uses? What is a situation, that was not talked about in class, where you would want to implement a chi-square test?

-OR-

Describe what areas you still feel uncomfortable with from the material. Please be specific, as this will help with my preparation for the final review.

Day 26 Discussion – Last Discussion

Posted Question:

My goal with having discussions was to have you, as a student, think about what we learned in class and apply it to your life to solidify your learning. In addition the discussions also gave you an opportunity to express your opinion about what you thought about the class, which I so much appreciated as the teacher! Please write 4-6 sentences about what you thought about the discussions, and how/if they helped your learning. (It may help you to look back at previous discussion to make an informative judgment.)

Thank you!